

## MEMORANDUM

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### To

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### **Richard Bolling Federal Building All Glass Door Breaks**

Over the course of four construction phases involving the modernization of the Richard Bolling Federal Building, to date 172 all glass door assemblies have been installed. Of these installed all glass doors, four are known to have failed within the last 6 to 7 years. The most recent failure was last month which injured a Social Security Association Employee requiring hospitalization and possibly rehabilitation due to a hand laceration apparently caused by falling tempered glass. This memo is an investigation of the breakages and an attempt to identify potential causes.

All Glass Door entrances are not new or a novelty construction assembly. They have been in fabrication since 1937 and are very common in today's building construction industry. Insulite, the Phase IV glass door fabricator fabricates and ships approximately 24 glass doors per week, and has seen roughly a dozen failures/placements in the last 25 years. All of those breaks were due to the edge of the tempered glass being hit by another object. Breakage is not a common occurrence and typically is related to an edge exposure to a solid object.

#### **1. History**

The design and construction team understands that there have been four all glass door breakages in recent years as indicated in the schedule below. We believe all but the most recent have had carts or buffers involved in the vicinity of the breakage. While all glass doors have been installed throughout the project, the breakages have only occurred in the pairs of all glass doors in the Streets in the Sky tower elevator lobbies separating public and tenant spaces. The specific doors that have broken have all been on the east leaf on the south side of the lobby.

The design team has not had the opportunity to review specific Field Office or FPS incident reports, so we do not know the details of each breakage incident.

Floor Lobby	Event	Year
15 <sup>th</sup> floor*	Goodwill Employee and Floor Buffer	2006 or 2007
15 <sup>th</sup> floor*	SSA Employee and Cart	2011 September
5 <sup>th</sup> floor	Goodwill or USACE Employee and Cart	2012 October
14 <sup>th</sup> floor	SSA Employee	2013 April

\* Believed to be the same door in each incident.

## 2. Assessment of Installed Doors

The first three breakages are believed to have involved an edge impact due to a cart, buffer or other objects. The most recent breakage last month apparently did not involve an immediate edge impact, which necessitated an evaluation of all the glass doors to determine if there was a visual observation that could explain the possible reason for glass door breakages. We had Bruce Frisbie with Insulite (Phase IV glass fabricator) visually inspect each glass doors and hardware that has been installed throughout the modernization of the building, and he prepared a spreadsheet (see Appendix A) to identify the doors and any visible defects or potential hardware problems. Outlined below are his comments covering the observations noted in the appendix.

- Door popping - 15th Floor South Streets in the Sky / Closer pop. The top insert on the patch fitting had been loose for some time and has caused wear in the top patch. They tightened the screws and made the entrance work considerably better but for a long term solution the patch will need to be replaced. They also noticed on this entrance that the Blumcraft handle has been previously removed and it looks like a piece of cardboard was used as a gasket when reinstalled, this should be addressed when this entrance is reworked.
- 7th Floor South Streets in the Sky / Closer Pop - The top insert on the patch fitting had been loose for some time and has caused wear in the top patch, they were not able to tighten the screws and suggested this patch fitting be replaced.
- 4th Floor South Streets in the Sky / Bottom Pivot Loose - They attempted to remove this door to see what was causing the loose pivot and found they could not remove the door due to the heads on the top patch screws being stripped out by others. The best way to remove this door would be drill out the screws and replace the complete patch. They removed the bottom rail end cap and from what they could observe while moving the door was that the pivot is not loose but does have wear in the pivot assembly. They suggest replacing the complete pivot assembly.
- Bruce noted that in his opinion all the doors they looked at with "popping" have been removed at one time or another by someone else and not necessarily reinstalled in the correct fashion and or with the right tools. Once they perform the necessary maintenance and repairs he is willing to have a short training session on the patch fittings and locking hardware. This training could occur in their shop, and video recorded, as they build new doors for this project.

While better qualified maintenance needs to happen with the doors, Bruce did not feel loose hardware and the items noted above would be cause for a door failure in their current condition. Doors requiring immediate attention have been repaired. JEDunn is preparing a proposal for the maintenance required with the entire scope of issues identified in the appendix.

## 3. Fabrication Quality Assurance

Representatives from the design and construction team visited Insulite's factory in Olathe, Kansas and reviewed the fabrication and tempering process. Attached are two PDF's showing the fabricators SGCC certificates and the test results on 12MM (1/2") glass. Besides sending glass to SGCC labs for testing, they also do daily testing in house to insure that they producing the finest quality glass possible. All factory tempered glass goes through three quality test procedures as outlined below.

- The first test is the LiteSentry ([www.litesentry.com](http://www.litesentry.com)) at the end of the tempering line. Every lite of glass that is tempered goes thru the Lite Sentry. The Lite Sentry they use is the Osprey 5 which is a distortion measurement system.
- The second test is a breakage test in which they pull a random lite of production glass off the end of the tempering oven and break it while it is lying flat to observe the break pattern. From this broken lite they retrieve the (10) largest piece and weigh them, record it and then bag them for record. This is done every hour of production and also at the start of every thickness change.

- The third test they do is with a GASP surface stress polarimeter ([www.strainoptics.com](http://www.strainoptics.com)) which reads the surface compression of the glass after it has been tempered. This is also done every hour of production and at the start of every thickness change.

Note that Insultite fabricated all of the glass for doors on the project (plate glass supplied by others). Both Insultite and Bratton (see Appendix) were involved in the installation of the door hardware which was supplied by different manufacturers. Multiple glazing sub-contractors installed the doors over the course of the renovations.

#### 4. Etched Glass

In addition to common locations in the elevator lobbies and the potential for cart damage, the doors where breakage has occurred have also been surface etched with a specialized process developed by Skyline glass in Chicago. Glass manufacturers such as PPG have identified criteria for etched tempered glass and its effect on the strength of the glass. Due to the slight etching process developed by Skyline, it is not believed that the tempered glass in any way is undermined by their surface etching process. Outlined below are questions the design team posed to Skyline and the response we received.

- Does the Eco-etch process compromise the structural integrity of the glass (see attached memo from PPG)? No. First and foremost, in reference to the PPG letter, Skyline Design does not "Sandblast" glass. Sandblasting is actually a fairly archaic method of creating decorative pattern on glass. To clarify, Skyline Design's Eco Etch process is a very light, highly automated abrasion process using a specially developed oxide powder. This powder has the consistency of talc or baby powder and in no way has the harsh abrasion qualities of sand. The finished aesthetic qualities and performance of the etching is similar to the appearance of acid etching but without using harsh chemicals in our production processes.
- Has the Eco-etch been used on similar all-glass doors elsewhere? In many projects throughout North America and abroad. Skyline Design is celebrating its 30<sup>th</sup> year this year and throughout our history we have Eco Etched thousands of frameless glass doors used in the commercial glazing industry and also for the furniture industry in applications such as demountable wall systems for manufacturers such as Haworth, Teknion, Dirtt etc.
- Have you seen this problem of all-glass doors shattering? In general no, within my personal history with the Skyline Design (26 years) it's a rare occurrence, both with frameless or framed door applications, glass spontaneously breaking is also very rare. Tempered safety glass is incredibly strong, however there are outside factors that can contribute to glass breakage such as improper handling, improper hardware specification, improper thickness to size specification, poor quality glass IE. Nickel Sulfide inclusions in glass (This can be ruled out due to multiple orders over a period of years and the glass came from multiple batches). Lastly, breakage can occur if the exposed glass edge comes into contact or is impacted with a heavy object or loads such as a tool box heavy metal cart, dolly etc... this can certainly cause the glass to fracture. The key factor is how the tempered glass breaks and that is fractures into small dull safe pebbles that meet ASTM standards.
- What does Skyline do to keep the glass stable when using the Eco-etch? Most glass that leaves our facility is safety glass, (tempered or laminated) this is required by code. In reference to tempered glass, our process of Eco Etching does not break or cut into the tension layer of the tempered surface.

#### 5. Destructive Testing

Insultite prepared a number of 24" x 36" x 1/2" tempered glass samples to demonstrate the relative strength of the glass when subjected to various external stresses. Knowing that the edge condition is the weakest point of any tempered glass unit, we also had them fabricate samples with a stainless steel edge channel to determine its improved resistance to panel edge breakage. Outlined below are the results of the breakage demonstrations (available on video at this link <https://www.box.com/s/4e4mlb0ayne4gy3i1g9x>).

- A 1/2" tempered glass sample was dropped on its corner repeatedly from a couple inches and sustained some visible damage to the corner (it also damaged the concrete floor) but did not fail.
- The same glass sample was then struck on the edge 16 times with a steel pipe with no breakage.
- The same panel was then struck on the edge with a large solid steel crowbar twice, and it then shattered.
- The next sample with stainless steel edge trim took 16 strikes on the edge with the same crowbar before it finally failed and broke the glass panel. There was significant signs of damage to the stainless steel trim from the crowbar strikes.
- The next sample was struck on the face of the glass 10 times with the steel crow bar with no breakage. The face of the glass resisted impact forces far greater than the edges of the glass.
- The sample was then struck with a steel punch tool along the edge. This is the same tool used to test fail units on the assembly line. As expected, the glass unit broke with the first punch.

- The punch was then used on a sample with a stainless steel edge trim. After 20 punches, the glass unit did not fail but the stainless steel showed visible signs of stress.
- It was noted that wherever the initial contact of breakage occurs, the small pieces of glass have a breakage pattern that radiates out from the point of contact. This could be useful in pinpointing the location and possible cause of future glass breakages.
- While tempered glass will break into tiny pieces, it may stay in larger clusters (still tiny pieces are held together in a light mechanical bond) until it falls and breaks apart into the smaller individual pieces.

## 6. Recommendations

All glass door assemblies provide a clean, open contemporary design aesthetic important to maintaining a culture of openness and transparency. Glass doors have been common in many applications for years and we have found no history of spontaneous breakage as these appear to be rare occurrences. When they do occur, it is commonly attributed to edge strikes or past edge strikes that may have weakened the tempered panel to the point that a lesser event may cause it to finally fail at some point in the future.

Based on our limited study and understanding of the breakage occurrences at the RBFB, we believe they are likely caused by significant edge impacts at the time of the event or have been fractured and weakened such that future stresses have resulted in the door failure. Outlined below are our recommendations for immediate implementation to try and minimize the potential for future breakages:

- Immediately repair all glass doors with hardware maintenance issues as identified in the glass survey.
- Due to the history of edge impacts on the glass doors, install a metal stainless steel “C” channel to the glass edge on the pivot and latch side of all glass doors to absorb strikes to the glass edges from foreign objects. This stainless steel edge will also serve as a measure for doors that take edge abuse by the marks that will be left in the stainless steel trim.
- It’s unknown if opening the doors beyond the 105 degree hold open angle can cause enough stress to break the glass but consideration should be given to adding floor and/or ceiling stops at doors in the elevator lobbies area where breakages have occurred) so they cannot be pushed beyond the doors hold open threshold.
- Have Insulite train GSA staff and contractors (Cimmaron) on being able to identifying damage and any necessary maintenance on all glass doors. Actual maintenance should only be performed only by qualified glazing professional such as Insulite.
- Implement a quarterly inspection program for all glass doors by GSA staff/contractors, and on a yearly basis by qualified personnel such as Insulite.
- GSA should implement a formal training program for building occupants to help them better understand how to operate the glass doors and necessary care for other building finishes and systems.
- If another break occurs, document in photographs the glass debris prior to any clean-up. This may help determine where the break occurred and the possible cause.
- It is the design team understands that door assemblies with “rails” perform the same as those with “patch” fittings. To demonstrate the strength of the current rail/patch fitting combination, a full scale mockup test of the glass assembly’s ability to resist torque in the surface of the glass with current hardware and hold opens can be performed. While not scientific, this test can provide antidotal evidence to help better understand the stressed threshold it takes to fail a glass door.
- Have the Field Office and FPS release accident/incident reports to the design team so that we have a clearer understanding of the breakage events and determine if the reports warrant revisions to these recommendations or further investigation.

Note that these findings and recommendations are based on our observations, discussions with others and limited research. A more detailed analysis by a consultant knowledgeable in materials research and engineering of glass door assemblies may be warranted to better understand the failures that have occur without the obvious causes such as carts and edge impacts.

## END OF MEMORANDUM

Attachment: Appendix A - Glass Door Survey  
SGCC Acknowledgment of Certification  
SGCC Impact Testing Report

## APPENDIX A - Glass Door Survey

Outlined below is a comprehensive glass door review by Bruce Frisbie with Insulite along with initial review comments as shown below:

### Loose pulls (qty. 86)

- Some are an ongoing maintenance issue, some are due to tampering with cylinders, locks, etc. (many are missing screws)
- Approx. 50% are loose at the top connection. If so, they can be tightened without removing the door
- If a pull is more than just loose at the top, door must be removed to tighten from underneath

### Rail Cladding Loose / End caps missing (qty. 7)

- Caused by striking rail, most likely with floor buffers

### Door bottom pivot loose (qty. 13)

- Caused by continued use and would be an ongoing maintenance issue
- Repair could involve removing door, cannot confirm until further investigation

### “Closer Pops” (qty. 21)

- See comments in item 2 of the report above.

### Closer leaking (3)

- Seals have failed on the closer and need to be replaced (fairly common)

### Chips (2)

- 11th and 13th Floors at edge of doors

MFG	DOOR MARK	HAND	ISSUES
Insulite	GSA -104	R	None
Insulite	GSA Conf. Room	R	None
Insulite	GSA Conf. Room	L	Pulls loose
Insulite	G05	R	None
Insulite	G52	L	Pulls loose
Insulite	G49	L	None
Insulite	G47	L	None
Insulite	G132	R	None
Insulite	G132	L	None
Insulite	G89	R	None
Insulite	G64	L	None
Insulite	G64	R	None
Insulite	FPS Main Conf. Rm.	R	None
Insulite	256	R	Pulls loose
Insulite	2 South Street	L	Pulls loose
Insulite	2 South Street	R	Pulls loose
Insulite	247	R	None
Insulite	254	R	None
Insulite	250	L	None
Insulite	254	L	None
Insulite	210	R	None
Insulite	204	R	None
Insulite	204	L	Pulls loose
Insulite	222	L	Pulls loose
Insulite	211	R	None
Insulite	300	L	Pulls loose
Insulite	300	R	Pulls loose

Insulite	301	L	IN USE
Insulite	352	L	None
Insulite	353	L	Pulls loose, Header clad loose
Insulite	355	R	Pulls loose, Rail clad loose
Insulite	367W	L	None
Insulite	331	R	Pulls loose
Insulite	335	R	Pulls loose
Insulite	349	L	Pulls loose
Insulite	313	R	Pulls loose
Insulite	322	L	Pulls loose
Bratton	4 South Street	R	Door portion bottom pivots / loose or need adjusted
Bratton	4 South Street	L	Door portion bottom pivots / loose or need adjusted
Bratton	4 North Street	R	Door portion bottom pivots / loose or need adjusted
Bratton	4 North Street	L	Door portion bottom pivots / loose or need adjusted / Int. pull apart
Bratton	417	R	None
Bratton	429	L	Pulls loose
Bratton	437	R	Pulls loose / Door portion bottom pivots / loose or need adjusted
Bratton	457	R	Door portion bottom pivots / loose or need adjusted
Bratton	455	R	Pulls loose / Door portion bottom pivots / loose or need 1adjusted
Bratton	445	R	Pulls loose/ Door portion bottom pivots / loose or need adjusted
Bratton	444		IN USE
Bratton	401		IN USE
Bratton	456	L	Pulls loose / Door portion bottom pivots / loose or need adjusted
Bratton	454	L	Pulls loose / Door portion bottom pivots / loose or need adjusted
Bratton	438	R	Pulls loose / Door portion bottom pivots / loose or need adjusted
Bratton	438	L	Pulls loose / Door portion bottom pivots / loose or need adjusted
Bratton	549	R	Pulls loose
Bratton	548	L	Pulls loose
Bratton	508	R	None
Bratton	509	R	Pulls loose
Bratton	510	R	Door portion bottom pivots / loose or need adjusted
Bratton	550	L	None
Bratton	551	R	Pulls loose
Bratton	527	R	Pulls loose
Bratton	527	L	None
Bratton	501	R	None
Bratton	501	L	Pulls loose
Bratton	552	R	None
Bratton	535	L	Pulls loose
Bratton	5 South Street	R	Pulls loose
Bratton	5 South Street	L	Pulls loose
Bratton	5 North Street	R	Pulls loose
Bratton	5 North Street	L	None
Bratton	6 South Street	R	Pulls loose / Missing screws in pulls
Bratton	6 South Street	L	Pulls loose / Missing screws in pulls
Bratton	6 North Street	R	Pulls loose
Bratton	6 North Street	L	Pulls loose
Bratton	659	R	Pulls loose
Bratton	647	R	Pulls loose
Bratton	665	L	None

Bratton	635	R	None
Bratton	601	R	None
Bratton	601	L	None
Bratton	641	R	Pulls loose
Bratton	647CD	L	Pulls loose
Bratton	611	R	None
Bratton	613	R	Pulls loose
Bratton	612	L	Pulls loose
Bratton	7 South Street	R	Pulls loose / Closer pop
Bratton	7 South Street	L	Pulls loose / Closer pop
Bratton	7 North Street	R	Pulls loose / Closer pop
Bratton	7 North Street	L	Pulls loose / Closer pop
Bratton	8 South Street	R	Pulls loose / Closer pop
Bratton	8 South Street	L	None
Bratton	8 North Street	R	Pulls loose
Bratton	8 North Street	L	Pulls loose / Closer pop
Bratton	802	L	None / Tenant states pulls hit alarm panel on wall
Bratton	801	R	Pulls loose
Bratton	801	L	None
Bratton	866	R	Pulls loose
Bratton	841	L	Pulls loose
Bratton	850	L	Pulls loose
Bratton	864	R	Closer pop
Bratton	864	L	Closer pop
Bratton	9 South Street	R	Pulls loose / Closer pop
Bratton	9 South Street	L	Pulls loose / Closer pop
Bratton	9 North Street	R	None
Bratton	9 North Street	L	Pulls loose
Bratton	965	R	None
Bratton	966	L	Broken end cap on hinge side
Bratton	902	L	Doorstop loose
Bratton	901	R	Pulls loose
Bratton	901	L	Pulls loose
Bratton	10 South Street	R	Pulls loose / Closer pop
Bratton	10 South Street	L	Pulls loose
Bratton	10 North Street	R	Pulls loose
Bratton	10 North Street	L	Pulls loose
Bratton	1001	R	Pulls loose
Bratton	1001	L	Pulls loose
Bratton	1044	R	None
Bratton	1044	L	None
Bratton	1044 Conf.	R	None
Bratton	1028 N	L	None
Bratton	1028 S	R	End caps loose
Bratton	1014	R	Doorstop loose
Bratton	1014 E	R	Pulls loose
Bratton	1102	R	Pulls loose
Bratton	1102	L	Glass chips on latch side
Insulite	1101	R	None
Insulite	1101	L	Pulls loose

Insulite	11 South Street	R	Pulls loose
Insulite	11 South Street	L	Pulls loose
Insulite	11 North Street	R	None
Insulite	11 North Street	L	Pulls loose
Bratton	1116	L	Pulls loose
Insulite	1125	L	Closer leaking
Insulite	12 South Street	R	Pulls loose
Insulite	12 South Street	L	Pulls loose
Insulite	12 North Street	R	Pulls loose
Insulite	12 North Street	L	Pulls loose
Insulite	12 PSC	R	Closer leaking
Insulite	1216	R	Closer leaking
Insulite	1216	L	Pulls loose / Closer leaking
Insulite	13 South Street	R	Pulls loose / Closer pop
Insulite	13 South Street	L	Pulls loose / Closer pop
Insulite	13 North Street	R	Glass chips on hinge side
Insulite	13 North Street	L	None
Bratton	1302	R	Closer pop
Bratton	1304	L	None
Insulite	1301	R	Pulls loose
Insulite	1301	L	Pulls loose
Insulite	14 South Street	R	Missing ext. side of pull / missing endcaps
Insulite	14 South Street	L	Loose clad on bottom rail
Insulite	14 North Street	R	Pulls loose / Closer pop
Insulite	14 North Street	L	Pulls loose
Insulite	1401	R	Pulls loose
Insulite	1401	L	Pulls loose / Closer leaking
Bratton	1402	R	None
Bratton	1402	L	None
Bratton	1502	R	Closer pop
Bratton	1502	L	Closer pop
Insulite	15 South Street	R	Pulls loose / Closer pop
Insulite	15 South Street	L	Pulls loose
Insulite	15 North Street	R	Door dragging on header / lower door
Insulite	15 North Street	L	None
Insulite	1501	R	None
Insulite	1501	L	Closer pop
Insulite	16 South Street	R	Pulls loose / Closer pop
Insulite	16 South Street	L	Pulls loose
Insulite	16 North Street	R	None
Insulite	16 North Street	L	Pulls loose
Insulite	1601	R	None
Insulite	1601	L	Pulls loose
Bratton	1604	R	None
Bratton	1604	L	None

END OF SCHEDULE